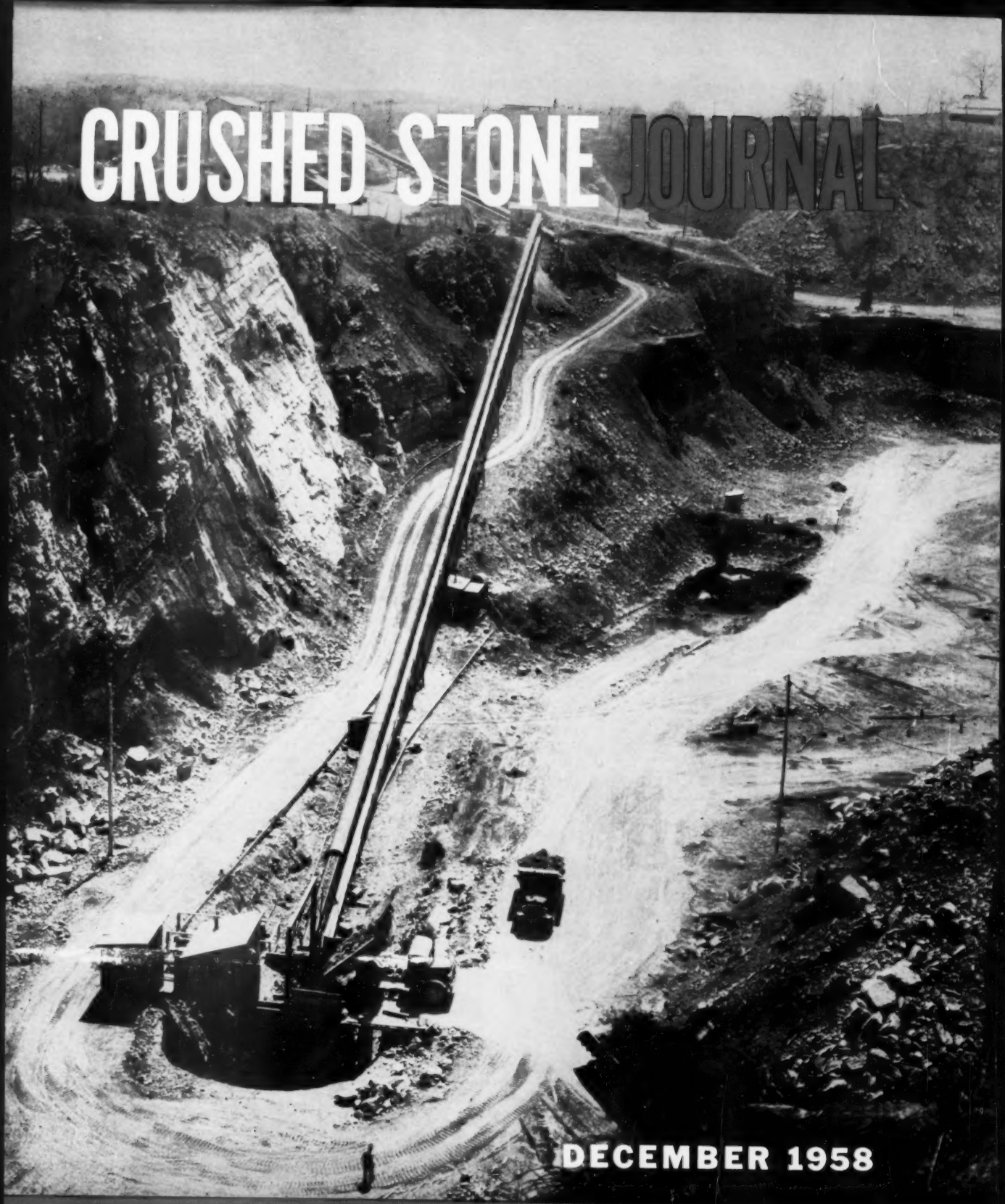
CRUSHED STONE JOURNAL



DECEMBER 1958

OFFICIAL PUBLICATION OF THE NATIONAL CRUSHED STONE ASSOCIATION

Technical Publications
of the
National Crushed Stone Association

STONE BRIEFS

No. 1. How to Proportion Workable Concrete for Any Desired Compressive Strength

No. 2. How to Proportion Concrete for Pavements

No. 3. Uses for Stone Screenings

No. 4. How to Determine the Required Thickness of the Non-Rigid Type of Pavement for Highways and Airport Runways

No. 5. The Insulation Base Course Under Portland Cement Concrete Pavements

ENGINEERING BULLETINS

No. 1. The Bulking of Sand and Its Effect on Concrete

No. 2. Low Cost Improvement of Earth Roads with Crushed Stone

No. 4. "Retreading" Our Highways

No. 5. Reprint of "Comparative Tests of Crushed Stone and Gravel Concrete in New Jersey" with Discussion

No. 7. Investigations in the Proportioning of Concrete for Highways

No. 9. Tests for the Traffic Durability of Bituminous Pavements

No. 11. A Method of Proportioning Concrete for Strength, Workability, and Durability. (Revised November 1953)

•

Single copies of the above publications are available upon request.

Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

Vol. XXXIII No. 4 PUBLISHED QUARTERLY December 1958

NATIONAL CRUSHED STONE ASSOCIATION

1415 Elliot Place, N. W.
Washington 7, D. C.

OFFICERS

O. E. BENSON, President
W. C. ROWE, Vice President
J. R. BOYD, Executive Director
J. E. GRAY, Engineering Director
A. T. GOLDBECK, Engineering Consultant

REGIONAL VICE PRESIDENTS

A. N. FOLEY
D. C. HARPER
R. G. L. HARSTONE
A. W. HEITMAN
J. L. HOLDEN
K. K. KINSEY
A. W. McTHENIA
N. SEVERINGHAUS
B. G. WOOLPERT

EXECUTIVE COMMITTEE

O. E. BENSON, Chairman
CLARENCE CAMP, II
CHARLES COBURN
L. A. EIBEN
N. E. KELB
H. C. KRAUSE
G. D. LOTT, JR.
R. S. REIGELUTH
W. C. ROWE
N. SEVERINGHAUS
D. L. WILLIAMS

EDITOR

J. R. BOYD

Contents

Page

Record Attendance Expected at 42nd Annual Convention 3

Standard Sizes for Coarse Aggregate By J. E. Gray 5

Highway Trust Fund Expected to Show Deficit by End of Fiscal 1960 8

Recent Developments and Practices in Concrete Paving By H. A. Radzikowski 9

Manufacturers Division Directory 18

AMERICANA • MIAMI BEACH, FLORIDA

HEADQUARTERS FOR THE 42nd ANNUAL CONVENTION

NATIONAL CRUSHED STONE ASSOCIATION

January 27-30, 1959

Record Attendance Expected at 42nd Annual Convention

WHEN the 42nd Annual Convention of the National Crushed Stone Association opens on January 27, 1959, it will bring close to one thousand people to the beautiful Americana, Miami Beach, Florida. Scheduled over a four-day period, the "42nd" promises to be the biggest off-show Convention ever held by NCSA.

Executives, salesmen, accountants, operating men, engineers, and superintendents will benefit greatly through discussions of improved methods and new techniques in the production of crushed stone. Supplementing the all important general and special Convention sessions will be the unparallelled opportunity for personal contacts between quarry men and equipment technicians from all over the United States.

General Session Kicks Off Convention

The Convention's first General Session convenes promptly at 9:15 a.m., Tuesday morning, January 27. The presiding officer will be NCSA President O. E. Benson, President of General Crushed Stone Company, Easton, Pennsylvania. His message of greeting to the assembled members and guests will be followed by brief reports from Executive Director, J. R. Boyd, and Engineering Director, J. E. Gray.

One of the primary responsibilities of any industry is the prevention of accidents. For a great many years the National Crushed Stone Association has made safety, through an active accident prevention program, one of its important functions. H. H. Kirwin, Chairman of the NCSA Accident Prevention Committee and Treasurer of Eastern Rock Products, Inc., Utica, New York, will report on "Safety Progress in the Crushed Stone Industry." Advance information indicates that you won't want to miss Mr. Kirwin's interesting presentation.

A. T. Goldbeck, NCSA Engineering Consultant, will describe the "First International Skid Prevention Conference," a subject of significance and importance to crushed stone producers. Also on the informative and interesting program of the opening day will be a short presentation by Arthur Goff, Chairman of the NCSA Cost Accounting Committee, President of the Wallace Stone Company, Bay Port, Michigan, on the new Accounting Manual for the Crushed Stone Industry.

Rounding out Tuesday morning's program will be a talk by John F. Lane of Gall, Lane and Howe, Washington, D. C., General Counsel for NCSA, which will be well worth listening to. His topic—"Startling Implications of Union Political Power."

Greeting Luncheon

At Tuesday's Greeting Luncheon, Clarence Camp, II, President of Camp Concrete Rock Company, Ocala, Florida, will preside; the new NCSA Officers and Executive Committee will be introduced by President Benson; following which James Westfield, Assistant Director of Health and Safety, U. S. Bureau of Mines, Washington, D. C., will present the hard won and well deserved awards for the NCSA Safety Contest.

Accountants Roundtable

On Tuesday afternoon, under the Chairmanship of Arthur Goff, there will be an informal Roundtable on the Application of the New NCSA Accounting Manual for the Crushed Stone Industry to discuss the specific and practical application of the Manual. John J. Fox, Partner of Lybrand, Ross Bros. & Montgomery, Certified Public Accountants, Detroit, Michigan, and Carl M. English, Associate of Gall, Lane and Howe, General Counsel, Washington, D. C., will be on hand to answer questions and assist with accounting problems.

At 6:00 p.m. there will be a Cocktail Hour where all in attendance at the Convention can relax in an informal atmosphere renewing old friendships and making new ones—the balance of the evening will be open for individual plans.

Operating and Sales Session

On Wednesday morning there will be two excellent and concurrent sessions, one on operating problems and the other on sales problems.

The Session for Operating Men and Equipment Manufacturers will be presided over by T. W. Jones, Vice President and Production Manager of the New Haven Trap Rock Company, New Haven, Connecticut. This session will get under way

promptly at 8:30 a.m. with "What Has Been Learned From Two Years of Quarry Efficiency Standard Record Keeping," by T. C. Cooke, President of Lynn Sand and Stone Company, Swampscott, Massachusetts. A Symposium on Ammonium Nitrate Explosives will follow with Frank J. Shalap, Vice President and General Manager of Graham Virginia Quarries, Occoquan, Virginia, discussing the "Use of Ammonium Nitrate Explosives in Quarry Operations;" Dr. Melvin A. Cook, Professor of Metallurgy and Director of Explosives Research Group, University of Utah, Salt Lake City, Utah, speaking on "Properties and Characteristics of Ammonium Nitrate as an Explosive;" and concluding this important symposium, Dr. Robert W. Van Dolah, Chief, Division of Explosive Technology, Region V, U. S. Bureau of Mines, Pittsburgh, Pennsylvania, speaking on "Some Considerations for the Safe Handling of Ammonium Nitrate Explosives."

The Session for Operating Men will be concluded with a talk by W. J. Parton, Assistant to the President of General Crushed Stone Company, Easton, Pennsylvania, speaking on the ever important problems involved in "Increasing the Capacity of Existing Plants."

The Session for Salesmen will be under the guidance of V. G. Aubry, Jr., Vice President in Charge of Sales for Houdaille Construction Materials, Inc., Morristown, New Jersey. This informative and enlightening session will provide your sales force with an opportunity to discuss new trends in selling, along with the tried and true techniques, which could well provide the clinching arguments necessary in making a difficult sale.

General Luncheon

A real treat is in store for those attending the General Luncheon on Wednesday, January 28. Samuel H. Ramsay, a Scotsman by birth and an American by choice, has captivated audiences all over the country with his brilliant and humorous stories. You won't want to miss hearing "Humor in Your Business" as Mr. Ramsay intrigues you with his droll New England humor and rapid fire delivery.

All of Wednesday afternoon and evening are open for your complete enjoyment of the lush semi-tropical splendor of Miami Beach, with its many attractions and numerous unique and exotic restaurants.

Executives and Operating Session

On Thursday, January 29, to appeal to the interest of all, concurrent sessions will again be the order of the day. The operating men will benefit from an unusual and very practical type of session new to NCSA Convention programs. Simultaneous roundtable discussions on such subjects as stripping; drilling and blasting; loading and quarry haulage; primary crushing and surge piles; secondary crushing and recrushing; stone sand production; conveying and screening; washing; stockpiling; implementing accident prevention practices; and underground operations, will take place throughout the room. The operating men attending this session will have an opportunity to sit in on any discussion for as long as they wish and then to move on to other subjects of their choice at the end of any one of the six 25 minute periods. This type of informal give and take discussion should prove highly informative and helpful to those in attendance.

A special Session for Executives, patterned after the highly successful Policy Makers Roundtable held at the last Convention, will provide members with an opportunity to discuss with John F. Lane, NCSA General Counsel, the federal statutes and administrative rules and regulations affecting the crushed stone industry and the conduct of your business.

Manufacturers Division Luncheon

At 12:30 on Thursday, the Manufacturers Division Luncheon, for members of the Manufacturers Division only, will be held. The newly elected Officers and Executive Committee of the Division will be introduced and members brought up to date on the activities of the Division.

Thursday afternoon will be open for relaxation and individual pleasures.

Hawaiian Luau

The Hawaiian Luau to be held Thursday night under the lovely Miami sky will thrill the hearts of all. At tables nestled in among stately palm trees, diners will feast on exotic foods prepared to tempt the most discriminating gourmets. The evening's entertainment will feature Hilo Hattie and her Hawaiian Revue with authentic native dances and the captivating songs of the Islands sung by talented vocalists in true Hawaiian style. Although the Hawaiian motif prevails throughout

(*Continued on Page 17*)

Standard Sizes for Coarse Aggregate

By J. E. GRAY

Engineering Director
National Crushed Stone Association
Washington, D. C.

IN the past 10 to 15 years the crushed stone industry has been rather successful in their constant endeavor to keep down costs through increased operating efficiency. However, there is another phase of this cost problem about which individual producers can do little, if anything, but which needs to be reviewed because of the large demand for aggregates for highway construction. This is the necessity of supplying a multiplicity of sizes as required under the specifications of various purchasing agencies.

Since the major outlet for aggregates is in highway construction, the specifications of the various state highway departments have a dominating influence on the sizes being produced. Any plant whose marketing area is solely within one state has little difficulty in supplying the necessary sizes. However, those producers who ship into two or more states almost invariably find trouble in meeting the specification requirements of such states. This condition is particularly regrettable because often the problem is one of minor differences in gradation limits of aggregate for use in the same type of construction. For example, in supplying coarse aggregate in two separate sizes for portland cement concrete paving, one state requires that the sizes be 2 to 3/4 in. and 3/4 in. to No. 4, while a neighboring state requires that the sizes be 2 to 1 in. and 1 in. to No. 4. The gradation of the combined sizes in each state is essentially the same; yet, different plant screens must be used to make these sizes and separate stockpiles must be maintained for each size.

Tolerances

The tolerances that should be and often are specified for the maximum size of stone are believed to have been neglected by producers in supplying material graded to the upper limit. It may be well to first define maximum size of coarse aggregate as the smallest laboratory sieve through which 90 per cent or more of the material will pass. For maximum sizes of 1 1/2 to 3 1/2 in., it is the usual practice to require 100 per cent to pass a 1/2 in. larger sieve than the maximum size; thus, for a nominal 2 to 1 in. size, 100 per cent should pass the 2 1/2 in. sieve and 90 to 100 per cent should pass the 2 in. sieve. The objections sometimes raised against oversized pieces even those within the tolerance limitation of the gradation requirements, has caused some producers to size stone to 100 per cent passing the nominal maximum size. For illustration, in the above example, many would size their aggregate to have 100 per cent passing a 2 in. sieve. When sampled from normal production this sizing procedure will usually show the true maximum size to be nearer 1 3/4 in. than 2 in. The effect of such sizing practices is to reduce the rate of production in tons of stone processed per hour. Proper tolerances are a necessary feature of any manufacturing process, including crushed stone, and their proper use is essential for the most economical production.

Suitable tolerances on the lower limit of size are of equal importance to those for the upper limit. For the coarser sizes, such as the 2 to 1 in. size previously mentioned, the usual tolerance on the lower limit is 0 to 15 per cent passing the 1 in. sieve with 0 to 5 per cent passing the 1/2 in. sieve. Little trouble is experienced with these usual tolerances in the coarse sizes, but when material is graded down to the No. 4 sieve with a tolerance of 0 to 5 per cent passing, often there is difficulty in keeping within this 5 per cent and at the same time maintaining a high rate of production. If the lower tolerance is a reasonable one, then the problem of producing within the limit is solved by having adequate screening area for the desired rate of production. The tolerances as established by the Simplified Practice Recommendation[1] are believed to be reasonable. While there have been some specifications that have tighter tolerances, especially on the lower limits, they have caused a drop in tons produced per hour. This may be desirable for certain sizes of stone used in surface treatment work, but should

[1] Simplified Practice Recommendation R163-48, Coarse Aggregate, U. S. Department of Commerce; sold by Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

TABLE I

Sizes of Coarse Aggregates

[Crushed stone, gravel, and slag]

Size Number	Nominal Size Square Openings [1]	Amounts Finer Than Each Laboratory Sieve (Square Openings), Percentage by Weight															
		4	3½	3	2½	2	1½	1	¾	½	⅜	No. 4	No. 8	No. 16	No. 50	No. 100
1	3½ to 1½	100	90 to 100	.....	25 to 60	.....	0 to 15	.....	0 to 5	.....	.....	.....	.....	.....	.....	.....
1-F [2]	3½ to 2	100	90 to 100	.....	.....	0 to 10	0 to 2	.....	.....	.....	.....	.....	.....	.....	.....	.....
2-F [2]	3 to 1½	.....	100	90 to 100	.....	.....	0 to 10	0 to 2	.....	.....	.....	.....	.....	.....	.....	.....
2	2½ to 1½	.....	.....	100	90 to 100	35 to 70	0 to 15	.....	0 to 5	.....	.....	.....	.....	.....	.....	.....
24	2½ to ¾	.....	.....	100	90 to 100	.....	25 to 60	.....	0 to 10	0 to 5	.....	.....	.....	.....	.....	.....
3	2 to 1	.....	.....	.....	100	95 to 100	35 to 70	0 to 15	.....	0 to 5	.....	.....	.....	.....	.....	.....
357	2 to No. 4	.....	.....	.....	100	95 to 100	.....	35 to 70	.....	10 to 30	.....	0 to 5	.....	.....	.....	.....
4	1½ to ¾	.....	.....	.....	.....	100	90 to 100	20 to 55	0 to 15	.....	0 to 5	.....	.....	.....	.....	.....
467	1½ to No. 4	.....	.....	.....	.....	100	95 to 100	.....	35 to 70	.....	10 to 30	0 to 5	.....	.....	.....	.....
5	1 to ½	.....	.....	.....	.....	.....	100	90 to 100	20 to 55	0 to 10	0 to 5	.....	.....	.....	.....	.....
56	1 to ⅜	.....	.....	.....	.....	.....	100	90 to 100	40 to 75	15 to 35	0 to 15	0 to 5	.....	.....	.....	.....
57	1 to No. 4	.....	.....	.....	.....	.....	100	95 to 100	.....	25 to 60	.....	0 to 10	0 to 5	.....	.....	.....
6	¾ to ⅜	.....	.....	.....	.....	.....	.....	100	90 to 100	20 to 55	0 to 15	0 to 5	.....	.....	.....	.....
67	¾ to No. 4	.....	.....	.....	.....	.....	.....	100	90 to 100	.....	20 to 55	0 to 10	0 to 5	.....	.....	.....
68	¾ to No. 8	.....	.....	.....	.....	.....	.....	100	90 to 100	.....	30 to 65	5 to 25	0 to 10	0 to 5	.....	.....
7	½ to No. 4	.....	.....	.....	.....	.....	.....	.....	100	90 to 100	40 to 70	0 to 15	0 to 5	.....	.....	.....
78	½ to No. 8	.....	.....	.....	.....	.....	.....	.....	100	90 to 100	40 to 75	5 to 25	0 to 10	0 to 5	.....	.....
8	⅜ to No. 8	.....	.....	.....	.....	.....	.....	.....	.....	100	85 to 100	10 to 30	0 to 10	0 to 5	.....	.....
89	⅜ to No. 16	.....	.....	.....	.....	.....	.....	.....	.....	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5	.....
9	No. 4 to No. 16	.....	.....	.....	.....	.....	.....	.....	.....	.....	100	85 to 100	10 to 40	0 to 10	0 to 5	.....
10	No. 4 to 0 [3]	.....	.....	.....	.....	.....	.....	.....	.....	.....	100	85 to 100	.....	.....	.....	10 to 30
G1 [4]	1½ to No. 50	.....	.....	.....	.....	.....	100	80 to 100	.....	50 to 85	.....	20 to 40	15 to 35	5 to 25	0 to 10	0 to 2
G2 [4]	1½ to No. 8	.....	.....	.....	.....	.....	100	65 to 100	.....	35 to 75	.....	10 to 35	0 to 10	0 to 5	.....	.....
G3 [4]	1½ to No. 4	.....	.....	.....	.....	.....	100	60 to 95	.....	25 to 50	.....	0 to 15	0 to 5	.....	.....	.....

[1] In inches, except where otherwise indicated. Numbered sieves are those of the United States Standard Sieve Series
[2] Special sizes for sewage trickling filter media
[3] Screenings
[4] The requirements for grading depend upon percentage of crushed particles in gravel. Size G1 is for gravel containing 20 per cent or less of crushed particles; G2 is for gravel containing more than 20 per cent and not more than 40 per cent of crushed particles; G3 is for gravel containing crushed particles in excess of 40 per cent

TABLE II

Typical Uses for Sizes Given in Table I

Use	Size Number and Nominal Size [1]																				
	1	1-F	2-F	2	24	3	357	4	467	5	56	57	6	67	68	7	78	8	89	9	10	G1	G2	G3
	3½ to 1½	3½ to 2	3 to 1½	2½ to 1½	2½ to ¾	2 to 1	2 to No. 4	1½ to ¾	1½ to No. 4	1 to ½	1 to ⅜	1 to No. 4	¾ to ⅜	¾ to No. 4	¾ to No. 8	½ to No. 4	½ to No. 8	⅜ to No. 8	⅜ to No. 16	No. 4 to No. 16	No. 4 to 0	1½ to No. 50	1½ to No. 8	1½ to No. 4
Water-bound macadam:																								
Coarse aggregate	x	.....	.....	x	.....	x	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Filler	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	.....	.....	.....
Bituminous macadam, penetration method:																								
Coarse aggregate	x	.....	.....	x	.....	x	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Choke	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	x	.....	x	x	.....	.....	x	.....	.....	.....	.....	.....	.....	.....
Seal	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	x	x	.....	.....	.....	.....
Bituminous plant mixes, base or surface courses: [2]																								
Base, open mix	.....	.....	.....	.....	x	x	.....	x	.....	.....	x	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Base, closed mix	.....	.....	.....	.....	.....	.....	x	.....	x	.....	.....	x	.....	x	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Binder course	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	.....	x	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Surface course, coarse grading	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	x	x	.....	x	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Surface course, fine grading	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	x	x	x	.....	.....	.....	.....
Seal	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	x	x	x	.....	.....	.....	.....
Bituminous road mix:																								
Mixing course	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	.....	.....	x	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Choke	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	x	x	.....	.....	.....	.....
Seal	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	x	x	.....	.....	.....	.....
Drag leveling course:																								
Leveling course	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	x	.....	x	.....	.....	.....	.....	.....	.....	.....
Seal	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	x	x	.....	.....	.....	.....
Bituminous surface treatment	.....	.....	.....	.....	.....	.....	.....	.....	.....	[3] x	[3] x	.....	x	x	x	x	x	x	x	x	.....	.....	.....	.....
Seal for airport construction	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	x	.....	.....	.....	.....
Portland cement concrete	x	.....	.....	x	.....	x	x	x	x	.....	.....	x	.....	x	.....	x	.....	.....	.....	.....	.....	.....	.....	.....
Railroad ballast:																								
Stone or slag	.....	.....	.....	.....	x	x	.....	x	.....	.....	x	x	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gravel	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	x	x
Roofing	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	.....	.....	.....	.....	.....	.....
Sewage trickling filter media	.....	x	x	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[1] In inches, except where otherwise indicated. Numbered sieves are those of the United States Standard Sieve Series
[2] For plant mixes the aggregate should consist of appropriate sizes selected from Table I combined with suitably graded fine aggregate
[3] Bottom course of multiple surface treatment

not be indicative of a general trend toward more restrictive tolerances without complete acceptance of reduced rate of production and, consequently, an increase in cost.

Range in Median

Almost all specifications for the sizing of aggregate attempt to embody the principle of reasonable tolerances for the upper and lower limits with a rather wide range for the median, in any given size. For example, in the 2 to 1 in. size, the amount passing the 1 1/2 in. sieve is often set at 35 to 70 per cent. In theory, aggregate is sized for the mid-point of the specifications or in this example, with 52 per cent passing the 1 1/2 in. sieve. Practice and theory are not always in agreement. Due to certain size demands, it may be advantageous to produce this 2 to 1 in. aggregate with 40 to 45 per cent passing the 1 1/2 in. sieve. The aggregate so produced complies with the specification and as long as it is uniform in gradation rarely does any trouble ensue. Now, let it be assumed that a specification writer is of the opinion that a 35 per cent spread of 35 to 70 in this median size is too large and that he wants more fine material and so writes a specification limiting this spread to 20 per cent, or 50 to 70 passing the 1 1/2 in. sieve. The large modern plant equipped with a blending belt to load out aggregate could easily adjust the discharge gates to the belt to supply stone in conformity with this more restrictive specification. On the other hand, a great many plants do not have blending belts, but make the sizes required and place them in stockpiles. In such operations, the producer is put to considerable trouble to change his plant flow to make another stockpile. The net effect is that either type of operation would have to supply more smaller size stone than is in demand for other uses. Generally, as the percentage spread on a given sieve becomes narrower and the size smaller, the rate of production is reduced and consequently the cost is increased.

The Problem

These problems on sizing are of little consequence for large jobs, but when supplying numerous medium to small jobs under many slightly varying specification requirements, they cause unnecessary trouble and are costly, especially when the stone is used for the same purpose in a great many cases. The primary cause of such problems is due to a lack of appreciation of what has been accomplished through the development of a national standard for sizing of coarse aggregate.

Its Solution

This national standard has been developed and accepted on a voluntary basis by the national specification writing organizations such as the ASTM, AREA, ACI, AASHO, the Federal Specifications Board, and in turn by most of the state highway departments. It is known as Simplified Practice Recommendation R163-48 for Coarse Aggregates (Crushed Stone, Gravel, and Slag). This recommendation was first promulgated in 1936, revised in 1939 and 1948, and will again be revised when in the opinion of the aggregates industries and of consumers there is a need for such action. These national standards have been in use for about 20 years. At the present time, it can safely be said that they have found widespread acceptance by both producers and consumers as having adequate range and reasonable tolerances with due consideration for economy of production.

In the intervening years since the last revision, there has been a tremendous increase in the number of engineers involved in writing aggregate specifications, so much so that many are not aware of these standard sizes. Often specifications for sizes of aggregate are written with the idea of improving on the past experience on a particular job, but without consideration for these national standards. These Simplified Practice Recommendations for sizes of coarse aggregates shown in Table I give the complete list of standard sizes which consist of nine primary sizes, designated by single digits, as No. 6, and nine combination sizes, designated by two digits, as No. 67. While it has been stated that these standard sizes have been adopted by all the national specification writing bodies, only those sizes which are particularly applicable to the specification at hand are specified, so that the background for many of these size requirements is frequently unknown. Of course, it is the intent of simplified practice recommendations that only these sizes which are applicable will be selected from Table I for incorporation in a specification. Table II lists typical uses for the sizes given in Table I. Since a number of sizes are used for the same purpose which encompasses the engineering practices in various

(Continued on Page 17)

Highway Trust Fund Expected to Show Deficit by End of Fiscal 1960[1]

THE Highway Trust Fund will show a deficit by the end of fiscal 1960.

Analysis of data affecting the operations of the Trust Fund indicates that, despite the present reserve balance of about $1 billion, there will be an estimated $1.36 million deficit at the end of fiscal 1960, and that this deficit will increase to more than $3,300 million in fiscal 1964. The graph of cumulative receipts and expenditures on this page shows how expenditures will exceed receipts in the next few years.

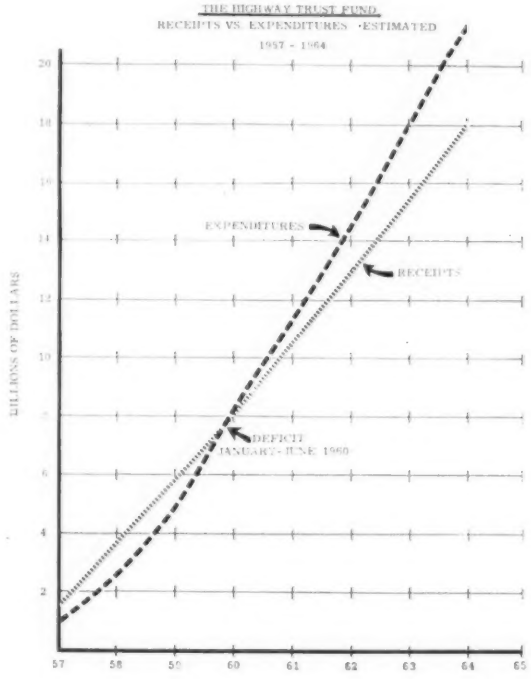
The critical condition of the Trust Fund was pointed up when the Director of the U. S. Bureau of the Budget suggested that—in order to provide the needed additional revenue—an increase in the tax on gasoline would be considered. According to reports of yield from the current three-cents-per-gallon federal tax on gasoline, it would take another two cents per gallon to provide the required amount.

Groups in the National Highway Users Conference, who recognized some time ago that a deficit was virtually inevitable, have taken a position favoring a contribution from the general fund to the Trust Fund to meet the need. They base their view on the fact that the present Trust Fund derives its entire revenue from special taxes on highway users, thus doing away with the concept of federal-aid. Federal-aid to roads has traditionally been one means whereby the Federal Government has discharged its constitutional obligations to the postal services, the national defense, and the general welfare. The importance of roads to national defense is being urged just now as a particularly strong reason for general funds aid to the highway program.

The opinion that the general fund should make up the Highway Trust Fund deficit may well gain support from the Section 210 Study now under way by the Bureau of Public Roads to determine the benefits from highways accruing to non-highway users. If the responsibility for the cost of the highways is then allocated in proportion to the benefits received, the highway users would be relieved of part of the burden of the 100 per cent responsibility which they now carry.

[1] Reprinted from Highway Highlights, October-November 1958

A factor in this thinking is the fact that the Highway Trust Fund, which came into being with the new highway program in 1956, began life with a $2 billion obligation. The reason is that it was charged with the responsibility for paying previous years' federal-aid authorizations not expended on the date the Trust Fund was set up.



It is reported that there is some sentiment in Congress for bond issues to add to the Trust Fund. This was proposed by the Clay Committee in 1954. In the face of widespread objections to the high interest cost, it was not adopted at that time.

Meanwhile, there is some opinion both in and out of Congress that the highway construction program should be limited to amounts available for expenditures in the Trust Fund as it is presently set up. This is in keeping with the thinking behind the temporarily suspended pay-as-you-go "Byrd Amendment." If adopted, this view would bring about a drastic cut-back in 1961 in the funds necessary to keep modernization of the

(*Continued on Page 17*)

Recent Developments and Practices in Concrete Paving[1]

By H. A. RADZIKOWSKI[2]

Chief, Division of Development, Office of Operations
Bureau of Public Roads, U. S. Department of Commerce
Washington, D. C.

Introduction

PORTLAND cement concrete was introduced as a paving material in the construction of city streets just before the turn of the century. Today it is recognized as an outstanding material for both urban and rural highway facilities.

In 1957 contracts were let for the equivalent of 5,000 lane miles of portland cement concrete paving on the federal-aid systems alone. A substantial mileage of the nation's better known expressways which have been completed to date or are under construction have used or plan for the use of portland cement concrete paving. These include such well known highways as the Pennsylvania Turnpike, the Baltimore-Washington Parkway, the New York Thruway, and the Ohio Turnpike, all of which are serving some of our highest traffic routes. Concrete paving, however, is not limited to the high traffic expressways, since there are many thousands of miles of concrete highways which serve the ordinary needs of states, cities, and counties.

As we merge from the preliminary stages of the most ambitious highway construction program in history and reach the point where completed mileage will become more significant, it might be well to review some of the recent progress that has been made in portland cement concrete paving equipment and practices and to take a glance into the future.

Compacting and Grading Equipment

To begin with there have been notable developments in equipment used to grade and compact the foundation courses which support portland cement concrete slabs. The multiple pad type vibrator which employs either electrical or hydraulic methods for vibration impulses has been used extensively on granular subgrades and base courses with outstanding results. The original machines were self contained units which operated on either crawlers or pneumatic tires. Last year several equipment manufacturers adapted the pad type vibratory attachments to such conventional units as the motor graders and three wheel rollers. Additions of the vibratory unit enabled the rollers to obtain densities well above those normally obtained by the basic equipment unit itself.

Other dynamic force compacting equipment which has been used with good results on foundation courses for concrete paving includes several models of towed type vibratory rollers, including a new unit with 72 in. drum. Greater use of the vibratory rollers seems to have been retarded because of the lack of a self propelled model suitable for highway construction.

Last year, however, a self propelled tandem roller of German manufacture was introduced in this country and has demonstrated its ability to surpass the performance of conventional type rollers in a number of compacting tasks. The 4 ton dead weight of the roller is converted into the equivalent of a 20 ton roller under vibration. The rate of vibration can be adjusted within a range of 2400 to 3400 vibrations per minute for various soil conditions. The roller has a driving width of only 39 1/2 in., but this apparent drawback is offset to a considerable extent by its ability to compact to the desired density in a fewer number of passes. It is believed that a self propelled vibratory roller having a roller width of 48 or 54 in. would gain more ready acceptance by American contractors.

This year an American manufacturer has placed on the market a 3 axle tandem roller with vibration on the middle roll. A greater degree of density with fewer passes and greater depth of compaction than possible with conventional type

---

1 Presented at the Paving Engineers Conference, Portland Cement Association, Knickerbocker Hotel, Chicago, Illinois, October 21, 1958

2 In collaboration with John J. Laing, Chief, Road Equipment Branch, Division of Development, Office of Operations, Bureau of Public Roads

steel wheel rollers is claimed for this machine. It should prove quite adaptable to the compaction of pavement foundations.

Pneumatic rollers have been used for a number of years in compacting pavement foundations. It is only recently, however, that self propelled models have been made available along with heavy ply tires which are capable of exerting contact or ground pressures up to and exceeding 100 psi. We in the Development Division believe that average contact or ground pressure ranges that the tires can exert should be one of the primary criteria for rating pneumatic rollers. Today, however, many individual factors such as wheel load, gross load, inflation pressure, and "weight per inch of tire width" are used to rate pneumatic rollers. None of these by themselves, however, give a true measure of the compacting ability of a pneumatic roller.

Several years ago an equipment manufacturer introduced a dual purpose roller having both steel wheel and pneumatic rolling units propelled by a two wheel tractor and having a wide range of contact pressures through ballast adjustment. There are a number of foundation conditions, including the compaction of sand lifts, where the combination of pneumatic tires and a steel roll will provide the desired density sometimes with only one pass. Last year the versatility of this machine was further increased by adding a trailing vibratory steel wheel roller and by providing alternate pneumatic and sheepsfoot rolls which are interchangeable with the steel roll which is located under the ballast box. These innovations provide a "3 to 1" roller which is adapted to a wide range of compaction jobs.

One of the most significant equipment developments which should be of interest to the concrete paving industry is the electronically controlled fine grading attachment for a motor grader. This interest should stem not only from the ability of this innovation to produce a smoother finished subgrade at lower cost and with less grade stakes, but also because of the possibilities of extending the automatic control principle to other units in the paving spread.

As now developed, the fine grading control maintains the grader blade in a level position or to a desired subgrade crown without interference from the irregularities which are encountered by the grader wheels.

In concrete paving a smooth subgrade conforming to planned profile is quite important, particularly when using a slip form paver, which will be analyzed a little later in this discussion.

Aggregate Upgrading Equipment

The road industry has been hampered for many years in areas subject to repetitive cycles of freezing and thawing by the presence of deleterious particles in aggregates used in paving work. Many specifications permit only a small percentage of such materials which has resulted in the high grading of aggregate deposits. Now, with many of the better deposits nearly exhausted, highway departments have been seeking some practical method of upgrading the less desirable deposits. One of the larger equipment manufacturers has recently developed an aggregate upgrading machine which makes use of the fact that soft particles have substantially different elastic or bouncing properties than hard durable stones.

Stones taken from the pit are conveyed into an overhead bin from which they are transferred by gravity to a vibratory feeder. The stones are then delivered from the lip of the feeder in a controlled manner so that they drop in a required pattern on the surface of a large inclined plate made of hard alloy steel. The hard stones of the gravel being processed will bounce in such a manner as to produce a characteristic distribution curve. The softer stones will also fall into a consistent but different curve pattern of shorter arc. Bounced stones are collected into three separate compartments with stones of similar elasticity being dropped into the same bins. The compartments are separated by adjustable dividers. One of these aggregate upgrading machines is located near Ann Arbor, Michigan. Our investigations reveal that this equipment shows excellent promise for the upgrading of gravels which do not contain cherts. Beneficiation costs are reported at 4 to 5 cents per ton.

Batching Equipment

Among the areas of concrete paving equipment that have undergone considerable improvement in recent years is the batching equipment for both aggregates and cement. Once charged, the electrically operated mechanically interlocked automatic batcher can be operated by a single operator, or even the truck driver, merely by pushing a button. Quantities of coarse and fine aggregates for various design mixes may be changed

instantaneously by punch cards which actuate an electronically controlled mechanism. This permits the batcher to handle several projects at the same time or to make prompt revisions where the variance of moisture contents in the aggregates affects the designed mix.

In view of the quality of control possible with this new equipment, one state highway department has indicated in its construction specifications issued in 1957 that automatic batchers will be required on all concrete paving projects after January 1, 1960.

In addition to the high capacity fixed plants, a portable trailer-mounted concrete batcher has been developed for ease of transfer. The unit holds 39 cu yd of aggregates, 280 barrels of cement, and 650 gal of water. This unit is also fully automatic. Once the weigh beams and water pointer are set along with the repeater for the desired number of batches, the measuring and discharge processes may be started with the push of a button.

New Type Concrete Mixers

Perhaps the newest innovation in concrete mixing equipment is the turbine type mixer of Swedish design which has been introduced in this country in sizes up to 1 1/2 cu yd. It is claimed that this doughnut shaped unit with the paddles revolving in a horizontal plane is capable of producing a homogeneous mix in 30 sec. Without wheel or crawler mounting, the unit is low and compact. It could be easily handled by a small crane on a paving job where the charging would be done outside of the paving area. After charging, the mixer could be transported during the mixing cycle and the completed mix deposited from the bottom discharge gate. Two 1 1/2 cu yd mixers of this type should be able to place a considerable volume of concrete per day if charging and discharging procedures can be streamlined.

The Slip Form Paver

The slip form paver, previously mentioned, is a relatively new and far reaching development in the concrete paving field. Several types have been developed in the last decade, but only one crawler model has undergone continuous improvement which appears to assure its widespread acceptance.

Ordinarily when we speak of a paver for constructing concrete pavements we are actually referring to concrete mixing equipment. Now a concrete lay down machine is available which performs the same function as a bituminous paver finisher. If the "slip form" paver continues to gain favor we may need some change in equipment nomenclature, since the impression that two types of "pavers" are required for concrete pavement construction might prove misleading. The slip form paver is essentially a single pass machine which combines spreading, vibrating, tamping, finishing, and belting in a single pass operation and, in addition, hauls its own forms into which a ribbon of dense concrete is extruded. The stability of the newly poured concrete prior to initial set is due to the simultaneous application of vibration and compression to a closely controlled harsh mix.

The one man-operated slip form paver not only eliminates the forms, equipment, and manpower for setting and pulling the forms, but also such single equipment items as spreaders, transverse finishers, and longitudinal finishers, all of which require individual operators. The slip form paver has been used successfully on both concrete base and finished pavements. Savings on pavement costs are in the scope of $0.40 per sq yd or up to $7,000 per mile of 24 ft slab.

As an indication that riding quality is not being sacrificed by the slip form method, it might be mentioned that an excellent smoothness (80 in. per mile when measured by the Bureau of Public Roads roughometer) was obtained on a finished non-reinforced concrete pavement which was placed on a soil cement foundation in Colorado last year. The smoothness compares favorably with the smoothness of pavements constructed with carefully placed forms. Since this smoothness was obtained with manually controlled equipment, it is believed that by using a motor grader with automatic blade controls and adopting electronic controls to the paver itself it should be possible to obtain even better adherence to the planned profile and cross section of the pavements. At the same time it might be possible to eliminate such units as a fine grader or planer from the already abbreviated slip form paving spread. Our Development Division is working with equipment manufacturers in developing abbreviated grading and paving spreads which are capable of producing better end products at reduced costs.

Placing Wire Mesh Reinforcement in Slip Form Paving

It appeared until a few months ago that the potentials of slip form pavers for portland cement concrete could be realized only on non-reinforced concrete slabs. A method was devised, however, during the current construction season by a Colorado paving contractor for incorporating wire mesh reinforcement into the newly formed slab in the single-pass operation. An experimental section of the 24 ft concrete paving one mile in length was laid on Interstate Route No. 25 near Denver, Colorado, in June 1958.

Specifications called for the mesh to be placed 2 in. from the top surface of the 8 in. slab with the method of achieving this placement left to the ingenuity of the contractor. To meet this placement requirement the contractor developed a sled type device which was attached to the forward arms of the slip form paver. This sled device is a U-shaped tool, with the outside longitudinal members made of small steel box girders, and welded to the front ends of these girders is a small I-beam with a 3 in. pipe across the full length of the top of the I-beam, and a 1 in. pipe was placed on the back to aid in the easy movement of the wire mesh.

As the slip form paver moved forward at speeds of 3 to 5 ft per min, the sled device lifted the mesh up from the grade and on to the sled runners. The concrete was then dumped from the paver bucket in front of and close to the strike off blade of the slip form paver, and as the strike off blade moved forward it pushed the concrete ahead and down through the mesh. After this and at a point where the sled runners had moved ahead from in under the mesh, the regular vibration, tamping and extrusion of the concrete took place, in the same manner that the slip form paver operates without mesh.

The pavement placed by this method is strictly homogeneous rather than being layered as is occasionally the case with the conventional formed pavement methods, where reinforcing is used. If the subgrade is carefully prepared, the slump of the concrete held consistently low, and good curing and sawing practices followed, the slip form paver with the sled attachment has been proven to be a time and money saving piece of equipment, which can produce an entirely satisfactory reinforced concrete pavement.

Although this initial try at placing wire mesh in a slip form paving operation was considered quite satisfactory in Colorado, it is felt that both the wire placing device and placing techniques can be improved to a considerable extent as a greater volume of reinforced slip form paving is undertaken.

Now that a major breakthrough has been made in concrete paving progress, it will be necessary to overcome some problems of lesser extent if the recently gained advantages are to be realized on a widespread basis. In some states it will be necessary to rearrange the cradles for dowel bar supports or to design some new load transfer device, such as a tongue and groove type, which will permit the ready placement of wire mesh in the single pass paving operation.

Improvements to Conventional Pavers

While some of the new paving equipment developments are gaining considerable attention at present, we do not want to overlook improvements to the old reliable pavers and supporting units which have been accomplished since World War II. Nearly all pavers are now of the high capacity dual compartment type which operate from outside of the forms rather than on the subgrade. First of all, we should mention that the automatic cycle of their operation begins when the skip leaves the ground and starts the first batch. Raising of the skip starts the water and activates the batchmeter, after which the mixing in the first drum proceeds while the skip is being loaded for the second batch. Initial loading is always in the first drum. Before the skip again reaches the top, all materials have been transferred from the first drum into the second drum so that mixing in both drums can proceed when the second skip is unloaded. Discharge from the second drum can be made only when the preset mixing time has elapsed. Hydraulic or pneumatic controls have been added to nearly all paver functions, including steering and brakes. Drum designs have been improved so that a more homogeneous mix without clogging or segregation of the materials is achieved. Dispensers for introducing air entrainment agents have been provided. Stub nose skips have been devised which eliminate the possibility of introducing foreign matter into the mix from the wheels of the batch truck.

Paver Mixing Time

While these improvements in paver mixer designs have been adequately field tested and accepted by a majority of the states, there appears to be some unresolved views in about one fourth of the states as to the relative performance of the modern dual compartment paver (34 E) as compared with the original 1 cu yd paver (27 E). These states employ mixing times of from 25 to 100 per cent over the 60 sec cycle recommended in the AASHO specifications for concrete paving which was adopted as an Association policy several years ago and which is generally followed by the majority of states. A 50 per cent increase in the 60 sec mixing time results in a loss of production of about 25 per cent.

Comprehensive tests conducted by the Bureau of Public Roads about 30 years ago on single drum pavers, including the 27 E size, show that good quality concrete can be produced in 45 sec, if the equipment is in good mechanical condition, and nothing of material value can be achieved by mixing concrete over 60 sec.

Several reasons have been advanced for the higher paver mixing time, including such explanations as:

1. Satisfaction with the concrete produced by the higher mixing times (which are based largely on tradition in the states involved)
2. Shortage of qualified paving inspectors
3. Tendency to undermix by lack of batchmeter control

None of these reasons appear to be valid in view of the preponderance of experience which points to the ability of modern pavers to meet specifications in a mixing time of 60 sec and the minimum of control needed to assure compliance with this cycle.

In order to recheck the concrete paver mixing cycle under the most modern practices and equipment improvements now available, the Physical Research Division of our Bureau, in cooperation with eleven state highway departments, has conducted mixing time tests on dual drum pavers during the current construction season. Mixing times of from 30 to 120 sec were employed in the tests.

While complete results of the tests have not been reported, observations and available test data verify the adequacy of a 50 to 60 sec mixing cycle for dual drum pavers with the overloads normally recommended by the equipment manufacturer. Some participants in the tests who are in the higher mixing time bracket have already indicated a willingness to reduce their time requirements and to permit overloads which were previously prohibited. It is hoped that when the full test results are made available, the remaining states employing the higher mixing cycles will revise their concrete paving specifications to provide for the lower mixing cycles.

Other Improvements in Paving Equipment Spreads

Other improvements in conventional paving spreads include the vibrating screeds and tampers on spreaders and finishers for handling the drier mixes, improved equipment for placing and removing forms, and the introduction of sprayers for applying liquid curing compounds.

The California Division of Highways has been using a positive action type tamper for a number of years in processing paving concrete. Several new models were developed in the last 3 to 4 years as attachments to finishers, and their use is becoming more widespread. The tampers do not replace the pan type vibrators, but supplement them in consolidating concrete. The tampers are fabricated from 2 in. wood stock with a steel plate on the bottom and obtain their vertical motion from connecting rods operating from an eccentric which is powered by a separate engine of 12 to 24 hp. The positive displacement furnished by the tamper provides additional force and depth over that derived from the conventional types having the tamper unit mounted on springs. The positive action tampers permit the use of drier mixes, particularly those containing crushed aggregates. Forcing down of the larger stones in the mix facilitates the final finishing and eases the wear on floats and longitudinal finishers.

Another new equipment unit which has been added because of the trend in forming joints in hardened concrete is the concrete saw which utilizes diamond or silicon carbide cutting discs. The use of narrow (maximum 1/4 in.) sawed joints tends to eliminate spalling, reduces maintenance effort, and provides smoother riding qualities. The use of sawed grooves to depths of 1 1/2 in. for both longitudinal and transverse joints also introduces problems when hard aggregates, such as chert gravel, are used. Several methods have been introduced to separate the stone and

form a weakened dummy joint composed of mortar. A vibrating joint forming machine has been developed for pours up to 24 ft. It rides the form behind the longitudinal float and employs a vibrating bar to form the transverse slot and a steel disc to form the longitudinal dummy joint. After the indentation is made, the wet concrete surface is smoothed over by a steel straight edge and broomed or belted.

Preforming of the sawed joints by these methods enables the sawing to be done in hard aggregate concrete at a cost that would be competitive in price with the sawing of concrete containing limestone or other softer aggregates.

Another method calls for placing a cardboard filler strip in the joints vibrated into the green concrete and sawing out the filler when the concrete has hardened.

Ready Mixed Paving Concrete

There has been an increase in the volume of ready mixed concrete, both from central plants and truck mixers in the postwar period. Available information indicates that over one half of the states are using this type on pavements. In one urban state the ready mix yardage comprises about 75 per cent of the total volume of paving concrete. All indications point to a further increase in ready mixed paving concrete.

Two factors undoubtedly could have a considerable influence on the magnitude of increase: (1) the large volume of concrete paving generated by the expanded highway construction program, (2) improvements in features of present ready mix practice, with respect to paving concrete, which are now under way.

Some of the states using ready mixed concrete are working on improvements in uniformity and quality of the end product, particularly in the transit mixes. In most areas the volume of paving concrete is a small percentage of the total volume of ready mixed concrete, and a problem exists in obtaining mixes which meet highway paving requirements. The equipment used in the transit mix industry varies to a considerable extent in design, and an effort is being made to have it maintained more closely to the standard normally demanded of equipment used by highway paving contractors.

One of the manufacturers of ready mix trucks has made an extensive study of other phases which he believed are involved in the quality of low slump truck mixed concrete such as used in paving. These phases were the methods of loading and the number of drum revolutions needed to adequately mix the concrete. In general, these extensive tests showed that the best uniformity, as measured by variance in relative strength, was obtained when the water was introduced first at the batching plant. The tests also showed that in most instances a minimum of 50 revolutions of the drum (5.0 cu yd size) was needed to assure desired uniformity. A rate of mixing of 7 to 8 rpm was found to produce the best results for transit mixes.

New developments in controlling the uniformity and slump of central plant mixed concrete seem to point towards an accelerated use of this method for concrete paving if problems associated with hauling and depositing can be overcome. Not only are highly sensitive moisture meters available which can determine moisture content in individual batches, but in addition a device has been developed which will automatically control the slump of concrete without regard to the variation in moisture content of the aggregates. The operation of this device takes into consideration the fact that the torque required to turn the mixer varies with the slump.

There is also the problem of segregation in discharging, particularly when dumping is employed. This later problem can be solved to a great extent by employing some kind of spreading equipment to receive and place the ready mix discharge.

Only a few months ago a new model of a spreader for receiving ready mixed concrete made its appearance on several concrete paving jobs. This unit has a bottom discharge spreader bucket which operates on transverse runners from which it can be in position on either side of the forms for loading. Upon loading, the bucket is moved transversely across the subgrade while placing a predetermined thickness of concrete which can be controlled from the bucket opening. Normally the bucket is returned to the loading side after the spreading pass. Placement of the concrete can be retarded, stopped or started at any point. As the spreader moves forward, the adjustable strike off screeds the concrete longitudinally. All movements of this new spreader are hydraulically powered.

Another conveyor belt model which has been used during the last 5 years is undergoing exten-

sive improvements by a new owner. A pilot model now in use shows great promise for the efficient spreading of concrete received from truck chutes or dump bodies. It is capable of handling a 20 to 25 ft slab of either single or two course construction. Two longitudinal conveyors which use the steel forms as a monorail are located in front of and behind a third transverse conveyor mounted in a cross frame. The longitudinal conveyors are capable of receiving two truck loads of concrete simultaneously. The concrete carried by the longitudinal belts is deposited on the transverse conveyor just inside the forms from which it is deposited evenly as the belt travels between forms in front of a strike off. The machine has a placing capacity of 3 to 4 cu yd per min.

Another of the problems associated with transit mix operations in urban areas is the disposal of partial or full batches of mixed concrete which for some reason cannot be placed. It has been reported that disposal costs of this residual concrete run as high as $20,000 per year for individual ready mix firms in some cities. A reclaiming plant has been developed by a concrete paving equipment manufacturer by which the aggregates are separated from the mixture by a combination of pressure washing and screening. The first unit has been installed at a central mix plant in Washington, D. C. After processing the mix, the coarse aggregate is actually cleaner than when originally used and may be returned to stockpiles for future use.

Additives

Not so many years ago the use of admixtures with portland cement concrete, regardless of the intended purposes, was generally discouraged. Today it is recognized that a number of additives are capable of improving the end product, particularly as to durability. Perhaps the most successful of the admixtures have been the air-entraining agents. Their almost universal adoption in areas subject to freezing and thawing has provided the most significant development in concrete paving technology since the 1930's. Durability and high resistance to cycles of freezing and thawing and to the applications of the chloride salts can now be built into concrete pavements with assurance. Calcium chloride and several proprietary compounds have been used successfully as cold weather protection. There are indications that the silicone solutions form an effective water repellent and minimize icing, particularly on concrete bridge slabs. Silicones have a high resistance to oxidation and the property of reversing the capillary attraction for water.

Final judgment on the long term benefit of these protective coatings will have to wait on the performance of a number of concrete pavements and bridge slabs which have received silicone treatments in the last several years.

Progress in Concrete Paving Research

Load transfer systems in transverse joints of concrete pavement have challenged the ingenuity of design engineers. A number of tests on dowels for shear resistance under static loads have been made. The Physical Research Division of the Bureau of Public Roads has recently completed a series of extensive repetitive loading tests on various doweled joint designs in which the forces and motions applied closely simulated actual service conditions. Some definite relationships between dowel diameters and load transfer capacities were found to exist from this comprehensive data.

A relationship was found to exist between slab depth and the dowel diameter required to transfer a given percentage of an applied load. It was indicated that, for minimum dowel size, the diameter in eighths of an inch should approximately equal the slab depth in inches.

Maximum load transfer capacity required 8 dowel diameters imbedment for 3/4 in. dowels and 6 dowel diameters imbedment for the 1 and 1 1/4 in. sizes, both initially and after many hundreds of thousands of repetitive loading cycles.

These findings should go far in promoting standardization of load transfer devices when provided for in plans.

End Result Specifications

While nearly all concrete paving specifications employ such end result requirements as compressive strength and profile smoothness, they also include many procedural requirements which have a direct bearing on the quality of the end product. Most concrete paving contractors operate with the benefit of years of experience. It might be desirable to consider means by which this experience could be used to a greater extent. Studies are being made to determine how much

emphasis could be placed on end result specifications by which only the desired thickness, strength, profile, and finish of concrete pavements would be specified along with essential limits of materials quality and control. Any step in this direction must of course be tempered with due consideration to the nature of concrete itself, including the minimum opportunity to make field corrections after placement and the cost of wholesale replacements necessitated by failure to meet an end result requirement.

New Testing Equipment

There are several developments in testing equipment used in conjunction with concrete pavement which should not be overlooked in this review. First, in connection with pavement foundation, a nuclear instrument has been developed for the rapid and accurate determination of subgrade density and moisture. This device is based on the varying degree that radioactivity is scattered when placed in contact with materials of different moisture content or density. Measurement or count of the amount of scatter is equivalent to measurement of moisture content or density, and may be read direct from a calibrated chart. Measurement of the average surface density to a depth of 6 in. can be obtained without probes merely by placing the base of the instrument on the surface. Determinations beyond that depth require the sinking of a pipe casing into which moisture and density probes may be inserted. This instrument was developed in conjunction with the U. S. Corps of Engineers and has been field tested on the AASHO road test at Ottawa, Illinois.

The Kelly ball, with and without modifications, is a relatively new device for the rapid field measurement of concrete consistency and is being used partially or exclusively in some eight states. The device consists of a metal bullet shaped nose of 6 in. diameter and 4 5/8 in. height which is fitted with a vertical measuring rod and mounted in a metal frame. The top portion of the measuring rod is formed into a loop which serves as a handle. The device is placed on the wet concrete with the measuring rod in a vertical position. The hemispherical nose settles into the concrete to a depth proportional to the consistency or slump of the placed concrete. In addition to saving time, several other advantages are claimed for the Kelly ball apparatus:

1. Elimination of sample preparation
2. Ease of operation promotes more frequent testing
3. It is more practical for testing concrete containing 2 in. + aggregate
4. It is easy to maintain

The Chase air meter for measuring the approximate air content in plastic concrete with known mortar content is another concrete testing device for field use which has been developed only recently. The apparatus is of simple construction and consists primarily of a tapered glass tube and a rubber stopper which can be easily carried in one's pocket. Tests for approximate air content can be completed in about 3 min.

The California Division of Highways has developed a portable "profilograph" which may be carried in the bed of a pickup truck. This straightedge device is used on both bituminous and concrete pavements to record the vertical deviations. On concrete pavements it is used principally to measure faulting, cracking, or curling even to a degree that might be attributed to temperature changes during the day. The profilograph records the vertical change in respect to the 25 ft interval between the front and back wheels. Five staggered wheels on each end of a longitudinal frame support it, and one wheel in the center connected to an inking pen records the exact deviation in profile on a horizontal scale of 25 ft to the in.

Future Needs and Prospects for Concrete Paving

Considerable credit is due to those who are responsible for the new methods, practices, and equipment which I have briefly described. Equipment manufacturers, for one, are not prone to rest on their laurels. They continue to explore zones where new developments are needed and where mechanization of present processes can be made more efficient. One of the bottlenecks being explored in on-the-job mixing is the truck batching and paver charging process which can easily prevent a paver from achieving its full production capacity. An entirely new concept for streamlining the field batching and charging process with trucks or some other loading units appears to be needed.

Current studies in paver mixing times will undoubtedly show that drum size is not the

controlling factor in establishing paver mixing cycles. This could lead to the development of larger pavers for on the job mixing purposes. Consideration is being given to the development of pavers as large as an 81 E size (3 cu yd) which could produce batches over twice the size now produced with the size 34 E paver. If a size 81 E paver is found to be practical, the correlation of the field batching and paving charging process would follow. Once a need is established, the equipment manufacturers can be depended upon to provide for it.

Standard Sizes for Coarse Aggregate

(*Continued from Page 7*)

areas of the country, it is obvious that these standard sizes are sufficient in number and range to provide for suitably graded aggregate.

The principle of simplified practice has been nationally accepted, but there are so many departures on the part of individual specification writers that a re-statement of this sizing recommendation is in order. It is suggested that the Simplified Practice Recommendation be studied and used wherever practical, and if there is a need for change of these sizes, it should be called to the attention of the National Crushed Stone Association so that revision can be requested when sufficient information is obtained in support of a proposed modification.

Record Attendance Expected at 42nd Annual Convention

(*Continued from Page 4*)

the evening the music for dancing is programmed to the tastes of the Mainlander. Every one will want to attend this evening full of fun and frolic.

Friday Features

The final session on Friday morning, January 30, will include talks on "Large Size Aggregate Bituminous Concrete Base Construction" by NCSA Field Engineer, H. M. Bixby, and "Bituminous Concrete Placing—Operation and Control" by Donald D. Dagler, District Engineer, Asphalt Institute, Harrisburg, Pennsylvania. "The Global Picture—Uncensored" will be presented by John Morley, internationally known free lance foreign correspondent.

For the Ladies

For the ladies, a special program has been planned assuring them a thoroughly delightful time throughout the 42nd Annual Convention. In addition to the special activities, many features of the regular Convention Program will be particularly appealing to the ladies—the Greeting Luncheon and Cocktail Hour on Tuesday, the General Luncheon on Wednesday, and, of course, the Hawaiian Party Thursday night.

Post Convention trips to some of the lovely Caribbean Islands have been scheduled and will be most relaxing for those taking a short vacation following the Convention. If you plan to take one of these Post Convention trips reservations should be made at once.

Plan Now to Attend

As you can see, the NCSA Convention Arrangements Committee has done an excellent job in putting together a Convention Program designed to be both profitable and practical, as well as enjoyable. Rare indeed will be the member or guest who leaves the 42nd NCSA Annual Convention without new ideas or a fresh approach to an old problem. Make your plans NOW to be at the Americana in Miami Beach, January 27-30, 1959.

Highway Trust Fund Expected to Show Deficit by End of Fiscal 1960

(*Continued from Page 8*)

Interstate System on schedule. In fact, it appears possible that there may be no apportionment of Interstate System funds for the year beginning July 1, 1960, unless the present situation is changed.

Whether any one or any combination of these proposals is adopted, or whether an entirely different plan is devised, is something Congress will have to decide. But, as of now, the Highway Trust Fund is heading for a deficit. A decision cannot be long delayed.

Attend the 42nd
NCSA ANNUAL CONVENTION
JANUARY 27 - 30, 1959
MIAMI BEACH, FLORIDA

Manufacturers Division
National Crushed Stone Association

•

These associate members are morally and financially aiding the Association in its efforts to protect and advance the interests of the crushed stone industry. Please give them favorable consideration whenever possible.

•

Acme-Hamilton Mfg. Corp.
Mead St., Trenton 3, N. J.
Conveyor and Transmission Belting, All Types of Industrial Hose and Sheet Packings

Allis-Chalmers Mfg. Co.
Milwaukee 1, Wis.
Crushing, Screening, Washing, Grinding, Cement Machinery; Motors; Texrope Drives; Centrifugal Pumps; Air Compressors; Hauling Equipment; Engines; Tractors

American Cyanamid Co.
Explosives and Mining Chemicals Department
30 Rockefeller Plaza, New York 20, N. Y.
Explosives, Blasting Supplies and Mining Chemicals

American Manganese Steel Division
American Brake Shoe Co.
155 North Wacker Drive, Chicago 6, Ill.
Manganese and Alloy Steel Castings, Power Shovel Dippers, Material Handling Pumps, Reclamation and Hard-Facing Welding Materials, Automatic and Semi-Automatic Welding Machines

American Pulverizer Co.
1249 Macklind Ave., St. Louis 10, Mo.
Manufacturers of Ring Crushers and Hammermills for Primary and Secondary Crushing and Laboratory Sizes

American Steel & Wire Division
United States Steel Corp.
Rockefeller Bldg., 614 Superior Ave., N. W., Cleveland 13, Ohio
Wire Rope, Aerial Wire Rope, Tramway Cables, Electrical Wires and Cables, Welded Wire Fabric, Wire and Strand for Prestressing Concrete, Wire Nails, Fencing, Netting

Aquadyne Corp.
89 Terminal Ave., Clark, N. J.
Dust Control Systems, Truck Bed Separating Agent

Arcair Co.
P. O. Box 431, Lancaster, Ohio
Metal Removal and Cutting Torches and Electrodes

Atlas Powder Co.
Wilmington 99, Del.
Industrial Explosives and Blasting Supplies

Austin Powder Co.
458 Rockefeller Bldg., Cleveland 13, Ohio
Explosives and Blasting Supplies

Bacon-Greene & Milroy
Division W. H. Milroy & Co., Inc.
P. O. Box 5276, Hamden 18, Conn.
Complete Crushing, Screening and Washing Plants "From Feeder Through Bin Gate," Farrel-Bacon Crushers for Primary and Secondary Operations, Feeders, Belt Conveyors, Bucket Elevators, Screens, Washing and Classifying Equipment, Wire Cloth, Drop Balls, Complete Plant Design

Baldwin-Lima-Hamilton Corp.
Construction Equipment Division
South Main St., Lima, Ohio
Power Shovels, Draglines, Cranes, Bins, Conveyors, Crushers, Feeders, Plants—Crushing and Portable, Washing Equipment, Asphalt Plants, Dust Control Equipment, Vibratory Compactors

Barber-Greene Co.
400 North Highland Ave., Aurora, Ill.
Portable and Permanent Belt Conveyors, Belt Conveyor Idlers, Bucket Loaders, Asphalt Mixing Plants and Finishers, Bucket Elevators, Screens

Birdsboro-Buchanan Crusher Dept.
Birdsboro Steel Foundry and Machine Co.
1941 Furnace St., Birdsboro, Pa.
Primary and Secondary Crushers and Rolls

Brunner & Lay Rock Bit of Asheville, Inc.
P. O. Box 5235, Asheville, N. C.
Tungsten Carbide Detachable Bits, "Rock Bit" Drill Steel Inlaid with Tungsten Carbide, Carbon Hollow Drill Steel, Alloy Hollow Drill Steel

Manufacturers Division – National Crushed Stone Association
(continued)

Bucyrus-Erie Co.

South Milwaukee, Wis.

Excavating, Drilling, and Material Handling Equipment

Canadian Industries Ltd.

P. O. Box 10, Montreal, Que., Canada

Commercial Explosives and Blasting Accessories

Cape Ann Anchor & Forge Co.

P. O. Box 360, Gloucester, Mass.

"Cape Ann" Forged Steel Drop Balls

Caterpillar Tractor Co.

Peoria 8, Ill.

Track-Type Tractors, Bulldozers, Earthmoving Scrapers, Motor Graders, Heavy-Duty Off-Road Hauling Units, Diesel Engines, Diesel Electric Generating Sets, Front End Shovels, Wheel-Type Tractors

Chain Belt Co.

P. O. Box 2022, Milwaukee 1, Wis.

Rex Conveyors, Elevators, Feeders, Idlers, Elevator Buckets, Drive and Conveyor Chains, Sprockets, Bearings, Pillow Blocks, Power Transmission Equipment, Portable Self-Priming Pumps, Concrete Mixers, Iron Castings

Clark Equipment Co.
Construction Machinery Division

P. O. Box 599, Benton Harbor, Mich.

Tractor Shovels; Tractor Dozers; Tractor Scrapers; Truck and Crawler Excavator-Cranes

Continental Gin Co.
Industrial Division

P. O. Box 2614, Birmingham 2, Ala.

Conveyors—Belt, Screw, Flight, and Underground Mine; Elevators—Bucket and Screw; Feeders—Apron, Belt, Reciprocating, Table, and Screw; Drives—V-Belts, Chains and Sprockets, Gears and Speed Reducers

Contractors and Engineers Magazine

470 Fourth Ave., New York 16, N. Y.

Magazine of Modern Construction

Cross Perforated Metals Plant
National-Standard Company

P. O. Box 507, Carbondale, Pa.

Cross Perforated Steel Segments, Sections, Decks, for Vibrating, Shaking, Revolving, and Other Types of Screening Equipment

Cummins Engine Co., Inc.

1000 Fifth St., Columbus, Ind.

Lightweight Highspeed Diesel Engines (60-600 Hp.) for: On-Highway Trucks, Off-Highway Trucks, Tractors, Earthmovers, Shovels, Cranes, Industrial and Switcher Locomotives, Air Compressors, Centrifugal Pumps, Generator Sets and Power Units, Work Boats and Pleasure Craft, Motor Graders

Dart Truck Co.

2623 Oak St., Kansas City 8, Mo.

Off Highway Trucks—End, Side, Bottom Dumps

Deister Machine Co.

1933 East Wayne St., Fort Wayne 4, Ind.

Deister Vibrating Screens, Classifiers, Washing Equipment

Detroit Diesel Engine Division
General Motors Corp.

13400 West Outer Drive, Detroit 28, Mich.

Light Weight, 2-Cycle Diesels for On- and Off-Highway Trucks; Tractors, Earthmoving and Construction Equipment; Electric Generator Sets and Industrial Power Units

Diamond Iron Works
Division Goodman Manufacturing Co.

Halsted Street & 48th Place, Chicago 9, Ill.

Jaw and Roll Crushers; Vibrator, Revolving, and Scrubber Screens; Drag Washers; Bucket Elevators; Belt Conveyors; Bins; Apron and Plate Feeders; Portable Gravel and Rock Crushing, Screening, and Washing Plants; Stationary Crushing, Screening, and Washing Plants; Hammermills

Drill Carrier Corp.

P. O. Box 628, Salem, Va.

"Air-Trac" Drill Carrier

Du Pont of Canada Limited

85 Eglinton Ave. E., Toronto 12, Ont., Canada

Explosives and Blasting Supplies

Du Pont, E. I., de Nemours & Co.

Wilmington 98, Del.

Explosives and Blasting Supplies

Dustex Corp.

25 Anderson Road, Buffalo 25, N. Y.

Dust Collecting Equipment; Dust Control Systems; Feeders

Manufacturers Division – National Crushed Stone Association
(continued)

Eagle Crusher Co., Inc.

900 Harding Way East, Galion, Ohio

Crushers; Pulverizers; Hammermills; 4-Cage Disintegrating Mills

Eagle Iron Works

P. O. Box 934, Des Moines 4, Iowa

Fine Material Screw Washers—Classifiers—Dehydrators; Coarse Material Screw and Log Washers—Dewaterers; Water Scalping and Fine Material Classifying Tanks; Stabilized Base Material Mixers; Drop Balls—Ni-Hard and Semi-Steel; "Swintek" Screen Chain Cutter Dredging Ladders; Revolving Cutter Head Dredging Ladders

Easton Car & Construction Co.

Easton, Pa.

Off-Highway Transportation: Quarry Hauling Systems—Heavy-Duty Dump Trailers, Truck Bodies, and Cars for Mines, Quarries, and Earth Moving

Electric Steel Foundry Co.

2141 N. W. 25th Ave., Portland 10, Oreg.

Esco Dragline Buckets, Shovel Dippers, Bucket Teeth, Crusher Wearing Parts, Cutting Edges and End Bits

Ensign-Bickford Co.

Hopmeadow St., Simsbury, Conn.

Primacord-Bickford Detonating Fuse and Safety Fuse

Euclid Division
General Motors Corp.

1361 Chardon Road, Cleveland 17, Ohio

Heavy-Duty Trucks and Dump Trailers for "Off-Highway" Hauls, Loaders for Earth Excavation, Single and Twin Engine Earth Moving Scrapers, Crawler Tractors

Frog, Switch & Mfg. Co.
Manganese Steel Department

Carlisle, Pa.

"Indian Brand" Manganese Steel Castings for all Types of Jaw, Gyratory, and Pulverizing Crushers; Dippers, Teeth, Treads, and Other Parts for Power Excavating Equipment; and Other Miscellaneous Manganese Steel Castings. Manufacturers and Fabricators of Railroad and Mine Frogs, Switches, and Crossings

Gardner-Denver Co.

South Front St., Quincy, Ill.

Portable and Stationary Compressors, Rock Drills, "Air-Tracs," Self-Propelled Drills, Sectional Drill Rods and Accessories, Air Hoists, Slusher Hoists, "Mole-Drills," Paving Breakers, Drill Steel, Gads, Etc.

General Electric Co.

1 River Road, Schenectady 5, N. Y.

Electric Motors, Controls, Locomotives, Coordinated Electric Drives for: Shovels, Drag Lines, Conveyors, Hoists, Cranes, Crushers, Screens, Etc.; Coordinated Power Generating and Distributing Systems Including Generators, Switchgear, Transformers, Cable, Cable Skids, Load Center Substations; Speed Reducers

Gill Rock Drill Co., Inc.

Lebanon, Pa.

Well Drill Tools and Supplies

Gilson Screen Co.

110 Center St., Malinta, Ohio

Testing Screens and Accessories for Test Sizing of Concrete Aggregates

Goodrich, B. F., Industrial Products Co.

500 South Main St., Akron, Ohio

Belting—Conveyor and V-Belts, Hose, and Industrial Rubber Products

Goodyear Tire & Rubber Co., Inc.

Akron 16, Ohio

Airfoam; Industrial Rubber Products—Belting (Conveyor, Elevator, Transmission), Hose (Air, Water, Steam, Suction, Miscellaneous); Chute Lining (Rubber); Rims (Truck and Tractor); Storage Batteries (Automobile, Truck, Tractor); Tires (Automobile, Truck, Off-the-Road); Tubes (Automobile, Truck, Off-the-Road, LifeGuard, Safety Tubes, Puncture Seal Tubes)

Gulf Oil Corp.
Gulf Refining Co.

Gulf Bldg., Seventh Ave., Pittsburgh 19, Pa.

Lubricating Oils, Greases, Gasoline and Diesel Fuels

Haiss, George, Mfg. Co., Inc.
Division of Pettibone Mulliken Corp.

4700 West Division St., Chicago 51, Ill.

Bucket Loaders, Buckets, Portable and Stationary Conveyors, Car Unloaders

Manufacturers Division – National Crushed Stone Association
(continued)

Harnischfeger Corp.

4400 West National Ave., Milwaukee 46, Wis.

A Complete Line of Power Cranes, Shovels, Draglines, Overhead Cranes, Hoists, Welders, Electrodes, Motors and Generators, Diesel Engines

HarriSteel Products Co.

420 Lexington Ave., New York 17, N. Y.

Woven Wire Screen Cloth

Hayward Co.

50 Church St., New York 7, N. Y.

Clam Shell Buckets, Electric Motor Buckets, Orange Peel Buckets, Automatic Take-Up Reels

Heidenreich, E. Lee, Jr.
Consulting Engineers

75 Second St., Newburgh, N. Y.

Plant Layout, Design, Supervision; Open Pit Quarry Surveys; Appraisals — Plant and Property

Hendrick Mfg. Co.

Carbondale, Pa.

Perforated Metal Screens, Perforated Plates for Vibrating, Shaking, and Revolving Screens; Elevator Buckets; Test Screens; Wedge Slot Screens; Wedge Wire Screens; Open Steel Floor Grating

Hercules Powder Co.

Wilmington 99, Del.

Explosives and Blasting Supplies

Hetherington & Berner, Inc.

701-745 Kentucky Ave., Indianapolis 7, Ind.

Asphalt Paving Machinery, Sand and Stone Dryers

Hewitt-Robins Incorporated

666 Glenbrook Road, Stamford, Conn.

Belt Conveyors (Belting and Machinery); Belt and Bucket Elevators; Car Shakeouts; Feeders; Industrial Hose; Screen Cloth; Sectional Conveyors; Skip Hoists; Stackers; Transmission Belting; Vibrating Conveyors, Feeders, and Screens; Design and Construction of Complete Plants; Molded Rubber Goods; Sheet Packing; Transmission Belting; Dewaterizers; Wire Conveyor Belts; Speed Reducers; Gears; Pulleys; Sheaves; Couplings

Howe Scale Co.

Strongs Ave., Rutland, Vt.

Scales, Static Weighing and Motion Weighing Devices, Automatic Batching Equipment

Hoyt Wire Cloth Co.

P. O. Box 1577, Lancaster, Pa.

Aggregate Wire Screens Made of Supertough, Abraso, and Stainless Steel Wire—Smooth-top, Longslot, Oblong Space and Double Crimp Construction—For All Makes of Vibrators; Rubber Bucker Up Channel

Hughes Tool Co.

P. O. Box 2539, Houston 1, Texas

Bits—Rotary Rock

Ingersoll-Rand Co.

11 Broadway, New York 4, N. Y.

Rock Drills, Paving Breakers, Paving Breaker Accessories, Quarrymaster Drills, Drillmasters, Waterwell Drills, Down-Hole Drills, Crawl-ir Drills and Wagon Drills, Carset Bits, Jackbits, Bit Reconditioning Equipment, Portable and Stationary Air Compressors, Air Hoists, Slusher Hoists, Pneumatic Tools, Centrifugal Pumps, Diesel and Gas Engines

Insley Manufacturing Corp.

P. O. Box 167, Indianapolis 6, Ind.

1/2 to 1 Cu. Yd. Cranes and Shovels 5 to 35 Ton Capacity with Rubber or Crawler Mounting; Crane Mountings Including Trucks, Self-Propelled Rubber-Tired Carriers and Crawlers; Concrete Buckets, Carts, and Hoppers

International Harvester Co.
Construction Equipment Division

P. O. Box 270, Melrose Park, Ill.

Crawler Tractors and Equipment, Rubber Tired Scrapers and Bottom Dump Wagons, Off-Highway Dump Trucks, Carbureted and Diesel Power Units

Iowa Manufacturing Co.

916 16th St., N. E., Cedar Rapids, Iowa

Rock and Gravel Crushing, Screening, Conveying and Washing Plants, Asphalt Plants, Stabilizer Plants, Impact Breakers, Screens, Elevators, Conveyors, Portable and Stationary Equipment, Hammermills, Bins

Manufacturers Division – National Crushed Stone Association
(continued)

Jaeger Machine Co.
550 West Spring St., Columbus 16, Ohio
Portable and Stationary Air Compressors, Self-Priming Pumps, Truck Mixers, Concrete Mixers, Road Paving Machinery, Hoists and Towers; Finishers—Concrete, Spreaders—Stone and Concrete, Truck Mixers—Concrete

Jeffrey Manufacturing Co.
815 North Fourth St., Columbus 16, Ohio
Elevator Buckets; Car Pullers; Chains; Conveyors: Belt, Drag, Apron, Vibrating; Idlers; Crushers; Pulverizers; Elevators; Feeders; Pillow Blocks; Grizzlies; Screens

Johnson-March Corp.
1724 Chestnut St., Philadelphia 3, Pa.
Dust Control Engineers, Chem-Jet Dust Control Systems, Gas Scrubbers

Joy Manufacturing Co.
333 Henry W. Oliver Bldg., Pittsburgh 22, Pa.
Drills: Blast-Hole, Wagon, Rock, and Core; Air Compressors: Portable, Stationary, and Semi-Portable; Aftercoolers; Portable Blowers; Carpullers; Hoists: Multi-Purpose and Portable; Rock Loaders; Air Motors; Trench Diggers; Belt Conveyors; "Spaders;" "String-a-Lite" (Safety-Lighting-Cable); Backfill Tampers; Drill Bits: Rock and Core; Joy Microdyne Dust Collectors

Kennedy-Van Saun Mfg. & Eng. Corp.
2 Park Ave., New York 16, N. Y.
Crushing, Screening, Washing, Conveying, Elevating, Grinding, Complete Cement Plants, Complete Lime Plants, Complete Lightweight Aggregate Plants, Synchronous Motors, Air Activated Containers for Transportation of Pulverized Material, Cement Pumps, and Power Plant Equipment

Kensington Steel
Division of Poor & Co.
505 East Kensington Ave., Chicago 28, Ill.
Oro Alloy and Manganese Steel Castings: For Shovels—Dipper Teeth, Crawler Treads, Rollers, Sprockets; For Crushers—Jaw Plates, Concaves, Mantles, Bowl Liners; For Pulverizers—Hammers, Grate Bars and Liners; For Elevators and Conveyors—Chain, Sprockets, Buckets; For Tractors—Rail Links, Sprocket Rims, and Grouser Plates; Drag Line Chain

Koehring Division
Koehring Co.
3026 West Concordia Ave., Milwaukee 16, Wis.
Excavating, Hauling, and Concrete Equipment

Link-Belt Co.
300 West Pershing Road, Chicago 9, Ill.
Complete Stone Preparation Plants; Conveyors, Elevators, Screens, Washing Equipment, and Power Transmission Equipment

Link-Belt Speeder Corp.
1201 Sixth St., S. W., Cedar Rapids, Iowa
Complete Line of Speed-o-Matic Power Hydraulically Controlled Cranes, Shovels; Hoes, Draglines, and Clamshells, 1/2 to 3-Yd. Capacities; Available on Crawler Base or Rubber Tire Mounting; Diesel Pile Hammers

Lippmann Engineering Works, Inc.
4603 West Mitchell St., Milwaukee 14, Wis.
Primary and Secondary Rock Crushers and Auxiliary Equipment such as Feeders, Screens, Conveyors, Etc., Portable and Stationary Crushing and Washing Plants

Ludlow-Saylor Wire Cloth Co.
634 South Newstead Ave., St. Louis 10, Mo.
Woven Wire Screens of Ludloy (Oil Tempered); Super-Loy (Hi-Carbon); Steel; Stainless Steel, and All Other Commercial Alloys

Mack Trucks, Inc.
1355 West Front St., Plainfield, N. J.
On- and Off-Highway Trucks, Truck-Tractors, Six-Wheelers, from 5 to 100 Ton Capacity, Both Gasoline- and Diesel-Powered

Manganese Steel Forge Co.
Richmond St. & Castor Ave.,
Philadelphia 34, Pa.
ROL-MAN 11.00 to 14.00 Per Cent Rolled Manganese Steel Woven and Perforated Screens, and Fabricated Parts for Aggregate Handling Equipment

Marion Power Shovel Co.
Division of Universal Marion Corp.
617 West Center St., Marion, Ohio
Power Shovels, Draglines, Cranes, Truck Cranes—From 3/4 to 75 Yd.

Marsh, E. F., Engineering Co.
4324 West Clayton Ave., St. Louis 10, Mo.
Belt Conveyors

Manufacturers Division – National Crushed Stone Association
(continued)

Mayhew Supply Co., Inc.

4700 Scyene Road, Dallas 17, Texas

Blast Hole Drill Rigs

McLanahan & Stone Corp.

252 Wall St., Hollidaysburg, Pa.

Complete Pit, Mine, and Quarry Equipment—Crushers, Washers, Screens, Feeders, Etc., Semi-Portable Plants

Meissner Engineers, Inc.

308 West Washington St., Chicago 6, Ill.

Engineers—Constructors—Specialists in Plant Layout, Construction-Engineering Design, Procurement, Construction Management, Quarry Surveys, Plant and Property Appraisals

Mercer Rubber Co.

136 Mercer St., Hamilton Square, N. J.

Belting—Conveyor, Elevator, and Transmission; Hose—Air, Water, Steam, Suction, Sandblast, Miscellaneous; Rubber Chute Lining

Monsanto Chemical Co.
Inorganic Division

Lindbergh and Olive Street Road,
St. Louis 24, Mo.

Prilled Ammonium Nitrate

Murphy Diesel Co.

5317 West Burnham St., Milwaukee 14, Wis.

Engines—Industrial Engine, and Power Units for Operation on Diesel and Dual Fuel Engines. Generator Sets, AC and DC from 64 Kw. to 165 Kw. Mech-Elec Unit—Combination Mechanical and Electric Power Furnished Simultaneously

New York Rubber Corp.

100 Park Ave., New York 17, N. Y.

Conveyor Belting: Stonore, Dependable, and Cameo Grades; Transmission Belting: Silver Duck Duroflex, Soft Duck Rugged, Commercial Grade Tractor

Nordberg Mfg. Co.

3073 South Chase Ave., Milwaukee 1, Wis.

Symons Cone Crushers, and Symons Gyratory and Impact Crushers; Gyradisc Crushers; Grinding Mills; Stone Plant and Cement Mill Machinery; Vibrating Screens and Grizzlies; Diesel Engines and Diesel Generator Units; Mine Hoists; Railway Track Maintenance Machinery

Northern Blower Co.

6409 Barberton Ave., Cleveland 2, Ohio

Dust Collecting Systems, Fans—Exhaust and Blower

Northwest Engineering Co.

135 South LaSalle St., Chicago 3, Ill.

Shovels, Cranes, Draglines, Pullshovels—Crawler and Truck Mounted

Olin Mathieson Chemical Corp.
Explosives Division

East Alton, Ill.

Explosives, Blasting Caps, Blasting Accessories

Pennsylvania Crusher Division
Bath Iron Works Corp.

323 South Matlack St., West Chester, Pa.

Single Roll Crushers, Impactors, Reversible Hammermills, Ring Type Granulators, Kue-Ken Jaw Crushers, Kue-Ken Gyratories, Non-Clog and Standard One-Way Hammermills

Pettibone Mulliken Corp.

4710 West Division St., Chicago 51, Ill.

Tractor Shovels, Front End Loaders, Swing Loaders, Yard Cranes, Bucket and Fork Loaders, Motor Graders, Manganese Steel Castings, Material Handling Buckets, Clamshells, Draglines, Pull Shovel Dippers, Shovel Dippers, and Pumps

Pioneer Engineering
Division of Poor & Co.

3200 Como Ave., Minneapolis 14, Minn.

Jaw Crushers, Roll Crushers (Twin and Triple), Impact Crushers, Hammer-Mills, Vibrating and Revolving Screens, Feeders (Reciprocating, Apron, and Pioneer Oro Manganese Steel), Belt Conveyors, Idlers, Accessories and Trucks, Portable and Stationary Crushing and Screening Plants, Washing Plants, Mining Equipment, Cement and Lime Equipment, Asphalt Plants, Mixers, Dryers, and Pavers

Pit and Quarry Publications, Inc.

431 South Dearborn St., Chicago 5, Ill.

Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Modern Concrete, Concrete Industries Yearbook, Equipment Distributor's Digest

Manufacturers Division – National Crushed Stone Association

(continued)

Productive Equipment Corp.
2926 West Lake St., Chicago 12, Ill.
Vibrating Screens

Quaker Rubber Division
H. K. Porter Co., Inc.
Tacony and Comly Sts., Philadelphia 24, Pa.
Conveyor Belts, Hose, and Packings

Reich Bros. Mfg. Co., Inc.
1439 Ash St., Terre Haute, Ind.
Rotary and "Down-the-Hole" Drilling Machines for Exploration, Coring, Blast Holes

Rock Products
79 West Monroe St., Chicago 3, Ill.
Publications: Rock Products and Concrete Products

Rogers Iron Works Co.
11th & Pearl Sts., Joplin, Mo.
Jaw Crushers, Roll Crushers, Hammermills, Vibrating Screens, Revolving Screens and Scrubbers, Apron Feeders, Reciprocating Feeders, Roll Grizzlys, Conveyors, Elevators, Portable and Stationary Crushing and Screening Plants, Mine Hoists, Drill Jumbos, Underground Loaders, Iron Castings, Screw Washers, and Classifying Tanks

Schramm, Inc.
West Chester, Pa.
Air Compressors: Portable and Stationary, Gasoline, Diesel, and Electric Driven; Boosters; PNEUMATRACTORS, Self-Propelled; Accessories; Bits—Rock: ROTATOOL Bits, Carbide Insert; Drills, Drilling Equipment; ROTADRILLS Mounted on PNEUMATRACTORS, Trucks and Crawlers; Ready-to-Mount ROTADRILLS for Mounting on Used Trucks and Crawler Tractors, ROTATOOLS for Bottom-Hole Drilling; Rock Drills; Wagon Drills; Breakers; Accessories

Screen Equipment Co., Inc.
40 Anderson Road, Buffalo 25, N. Y.
Seco Vibrating Screens; Scales—Industrial, Aggregates, Truck

Simplicity Engineering Co.
Durand, Mich.
Simplicity Gyrating Screens, Horizontal Screens, Simpli-Flo Screens, Tray Type Screens, Heavy Duty Scalpers, D'Watering Wheels, D'Centegrators, Vibrating Feeders, Vibrating Pan Conveyors, Car Shake-Outs, Woven Wire Screen Cloth, Grizzly Feeders

SKF Industries, Inc.
P. O. Box 6731, Philadelphia 32, Pa.
Anti-Friction Bearings—Self-Aligning Ball, Single Row Deep Groove Ball, Angular Contact Ball, Double Row Deep Groove Ball, Spherical Roller, Cylindrical Roller, Ball Thrust, Spherical Roller Thrust; Tapered Roller Bearings; Pillow Block and Flanged Housings—Ball and Roller

Smith Engineering Works
532 East Capitol Drive, Milwaukee 12, Wis.
Gyratory, Gyrasphere, Jaw and Roll Crushers, Vibrating and Rotary Screens, Gravel Washing and Sand Settling Equipment, Elevators and Conveyors, Feeders, Bin Gates, and Portable Crushing and Screening Plants

Soiltest, Inc.
4711 West North Ave., Chicago 39, Ill.
Laboratory and Field Testing Apparatus: Drilling and Coring Rigs, Sieve Shakers, Sieves, Scales, Balances, Calibration Equipment, Abrasion Testing Machines, Ovens and Furnaces

Sprengnether, W. F., Instrument Co., Inc.
4567 Swan Ave., St. Louis 10, Mo.
Portable Blast and Vibration Seismograph, and Scientific Instruments

Stardrill-Keystone Co.
920 East 17th St., Beaver Falls, Pa.
Drilling Machines: Rotary Air Drills, Churn Drills, Rotary Tools, Rotary Bits, Down-the-Hole Guns, Insert Type Bits, and Water Well Drills

Stedman Foundry & Machine Co., Inc.
P. O. Box 209, Aurora, Ind.
Stedman Impact-Type Selective Reduction Crushers, 2-Stage Swing Hammer Limestone Pulverizers, Multi-Cage Limestone Pulverizers, Vibrating Screens

Stephens-Adamson Mfg. Co.
Aurora, Ill.
Belt Conveyors, Pan Conveyors, Bucket Elevators, "Amsco" Manganese Steel Pan Feeders, Vibrating Screens, Belt Conveyor Carriers, Bin Gates, Car Pullers, "Sealmaster" Ball Bearing Units, "Saco" Speed Reducers, and Complete Engineered Stone Handling Plants

Taylor-Wharton Co.
Division Harsco Corp.
High Bridge, N. J.
Manganese and Other Special Alloy Steel and Iron Castings; Dipper Teeth, Fronts and Lips; Crawler Treads; Jaw and Cheek Plates; Mantles and Concaves; Pulverizer Hammers and Liners; Asphalt Mixer Liners and Tips; Manganese Nickel Steel Welding Rod and Plate; Elevator, Conveyor, and Dredge Buckets; Pan Feeders

Manufacturers Division – National Crushed Stone Association
(continued)

Thew Shovel Co.

East 28th St. and Fulton Rd., Lorain, Ohio

"Lorain" Power Shovels, Cranes, Draglines, Clamshells, Hoes, Scoop Shovels on Crawlers and Rubber-Tire Mountings: Diesel, Electric, and Gasoline, 3/8 to 2 1/2 Yd. Capacities; Thew Moto-Loader—Rubber-Tire Front End Loader 1 3/4 and 2 Yd. Capacity

Thor Power Tool Co.

175 North State St., Aurora, Ill.

Wagon Drills, Rock Drills, Sump and Sludge Pumps, Clay Diggers, Paving Breakers, Quarry Bars, Sinker Legs, Drifters, Rock Drilling Jumbos, Raiser Legs, Push Feed Rock Drills, Air and Electric Tools, Accessories, Generator Sets, Concrete Vibrators, Power Trowels, Vibratory Screeds

Torrington Co.
Bantam Bearings Division

3702 West Sample St., South Bend 21, Ind.

Anti-Friction Bearings; Self-Aligning Spherical, Tapered, Cylindrical, and Needle Roller; Roller Thrust; Ball Bearings

Tractomotive Corp.

County Line Road, Deerfield, Ill.

Rubber Tired Front-End Loaders (Tracto-Loaders)

Traylor Engineering & Mfg. Co.

Allentown, Pa.

Stone Crushing, Gravel, Lime, and Cement Machinery

Trojan Powder Co.

17 North Seventh St., Allentown, Pa.

Explosives and Blasting Supplies

Tyler, W. S., Co.

3615 Superior Ave., N. E., Cleveland 14, Ohio

Woven Wire Screens; Ty-Rock, Tyler-Niagara and Ty-Rocket (Mechanically Vibrated) Screens; Hum-mer Electric Screens; Ro-Tap Testing Sieve Shakers, Tyler Standard Screen Scale Sieves, U. S. Sieve Series

Universal Engineering Corp.
Subsidiary of Pettibone Mulliken Corp.

625 C Ave., N. W., Cedar Rapids, Iowa

Jaw Crushers, Roll Crushers, TwinDual Roll Crushers, Hammermills, Impact Breakers, Pulverizers, Bins, Conveyors, Feeders, Screens, Scrubbers. Bulldog Non-Clog Moving Breaker Plate and Stationary Breaker Plate Hammermills, Center Feed Hammermills. A Complete Line of Stationary and Portable Crushing, Screening, Washing, and Loading Equipment for Rock, Gravel, Sand, and Ore. Aglime Plants. Asphalt Plants

Vibration Measurement Engineers, Inc.

725 Oakton St., Evanston, Ill.

Seismographic and Airblast Measurements, Seismological Engineering, Blasting Complaint Investigations, Expert Testimony in Blasting Litigation; Nation-wide Coverage; A Complete Seismograph Rental and Record Analysis Service With "Seismolog"

Werco Steel Co.

2151 East 83rd St., Chicago 17, Ill.

Castings—Manganese, Alloy Steel; Screen Plates—Perforated Steel Screen Sections and Decks; Buckets; Chains; Belt Conveyors, Idlers; Dipper—Shovel; Drop Balls; Wire Cloth; Wire Rope and Related Products; Crushers, Pulverizers

Western-Knapp Engineering Co.

50 Church St., New York 7, N. Y.

Plant Design and Construction; Operating Studies; Appraisals

White Motor Co.

842 East 79th St., Cleveland 1, Ohio

On- and Off-Highway Trucks and Tractors—Gasoline- and Diesel-Powered; Industrial Engines—Gasoline and Diesel; Power Units, Axles, Special Machine Assemblies; Power Generating and Distributing Systems; Batteries; All Classes of Maintenance and Repair Service

White Motor Co.
Autocar Division

Exton, Pa.

Motor Trucks

Wickwire Spencer Steel Division
Colorado Fuel and Iron Corp.

575 Madison Ave., New York 22, N. Y.

Wire Cloth, Screen Sections, Screen Plate—Perforated Steel, Wire Rope—Slings

Williams Patent Crusher & Pulverizer Co.

2701-2723 North Broadway, St. Louis 6, Mo.

Hammer Mills, Crushers, Pulverizers, Roller Mills, Reversible Impactors, Vibrating Screens, Air Separators, Bins, and Feeders

NATIONAL CRUSHED STONE ASSOCIATION
NCSA
1918